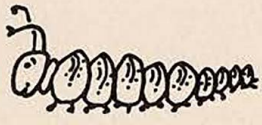
PROCEEDINGS

THIRTY-FOURTH ANNUAL WESTERN FOREST INSECT WORK CONFERENCE



SANTA ROSA, CA

MARCH 1-3, 1983

PROCEEDINGS

THIRTY-FOURTH ANNUAL WESTERN FOREST INSECT WORK CONFERENCE

SANTA ROSA, CALIFORNIA

MARCH 1-3, 1983

Not for Publication

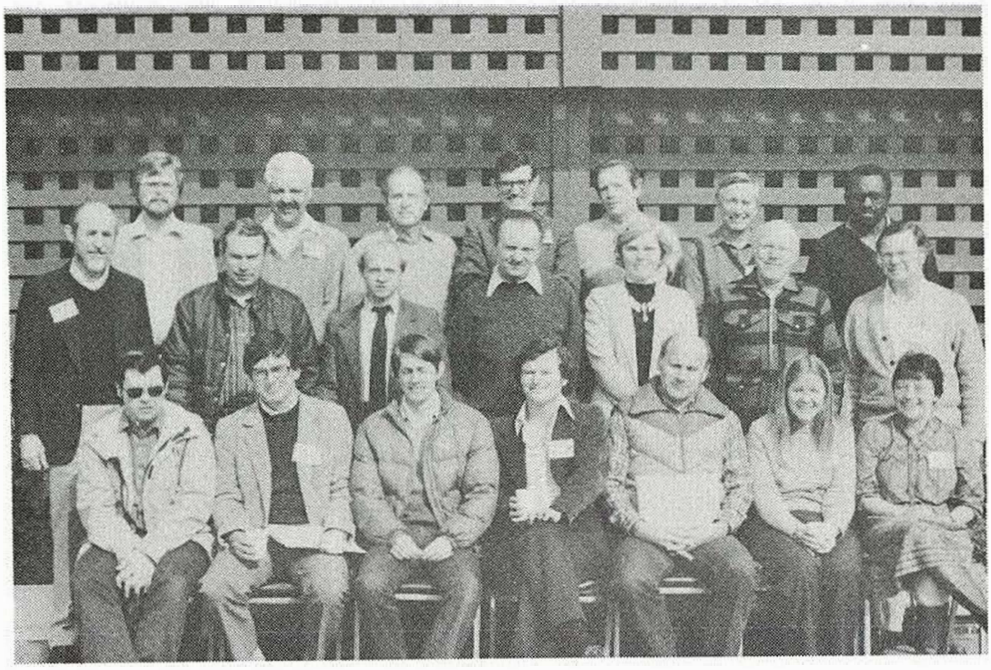
(For Information of Conference Members Only)

Prepared and Printed at

Pacific Northwest Region

USDA Forest Service

Portland, Oregon



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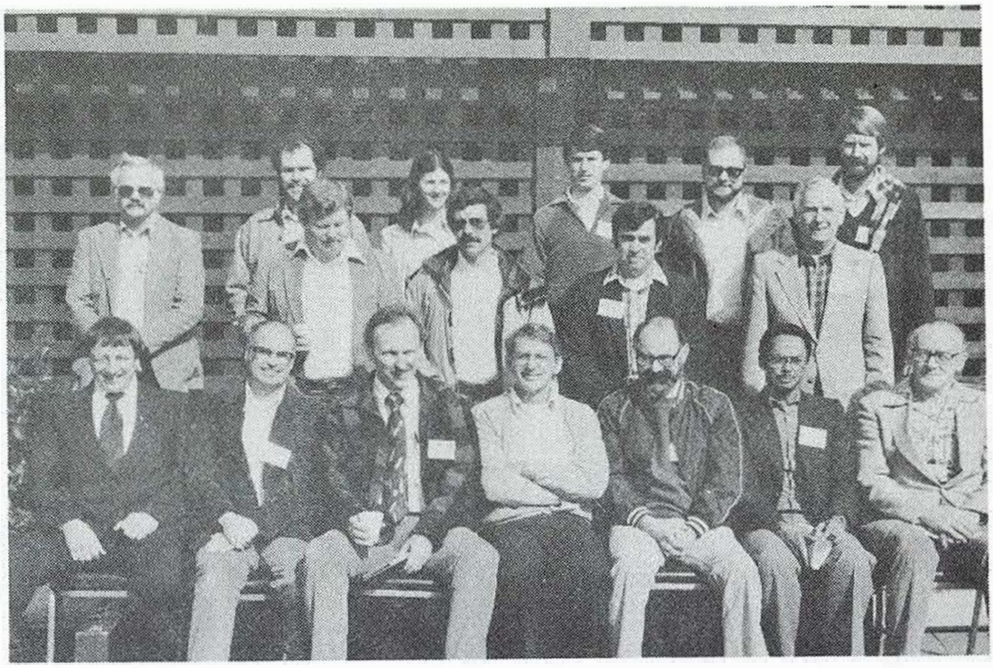
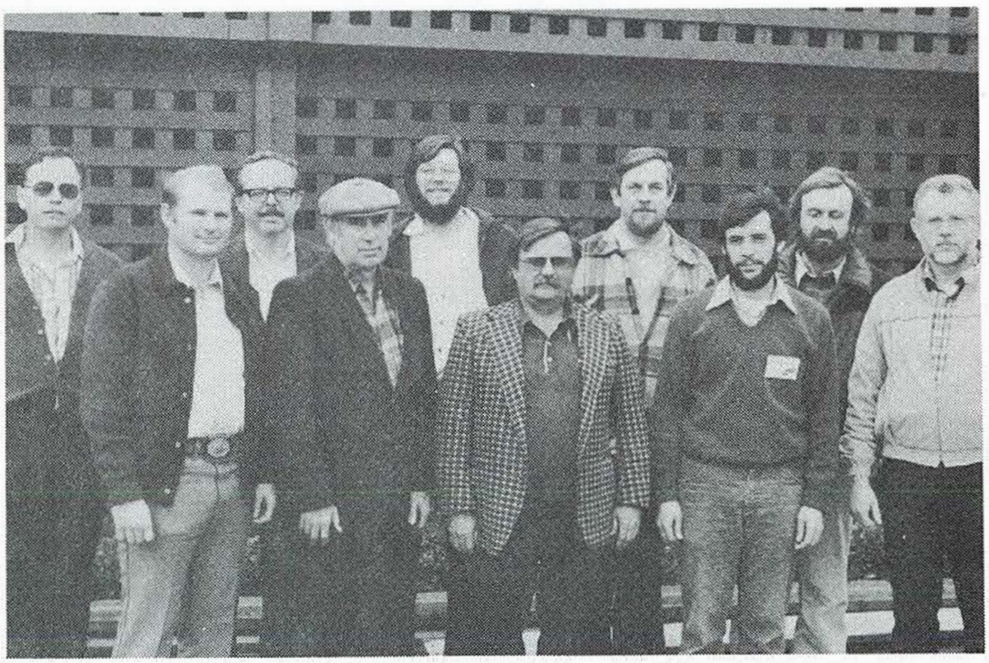
First Row, l-r: John Pierce, Gordon Miller, Mike Hulme, Roy Shepherd, Torolf Torgersen, Bob Celaya, John Moser. Second Row: Dale Kirkbride, John DeBenedictis, Arthur Raske, Elizabeth Blake, Debbie McCullough, Ken Miller, Third Row: Dan Miller, Bill Telfer, Lincoln Moore, Bernie Raimo, J. Robert Bridges, Gerry Lanier, David Hunt.



First Row, l-r: Larry Freeman, Wayne Bousfield, G. D. Hertel, Dick Smith, Paul Buffam, Ben Moody, Ron Stark. Second Row: Ken Swain, Fred Stephen, Jim Linnane, Harry Johnson. Third Row: Donn Cahill, Roy Hedden, Kathy Sheehan, Jeff Corneil, Dave Schultz, Tim Paine.



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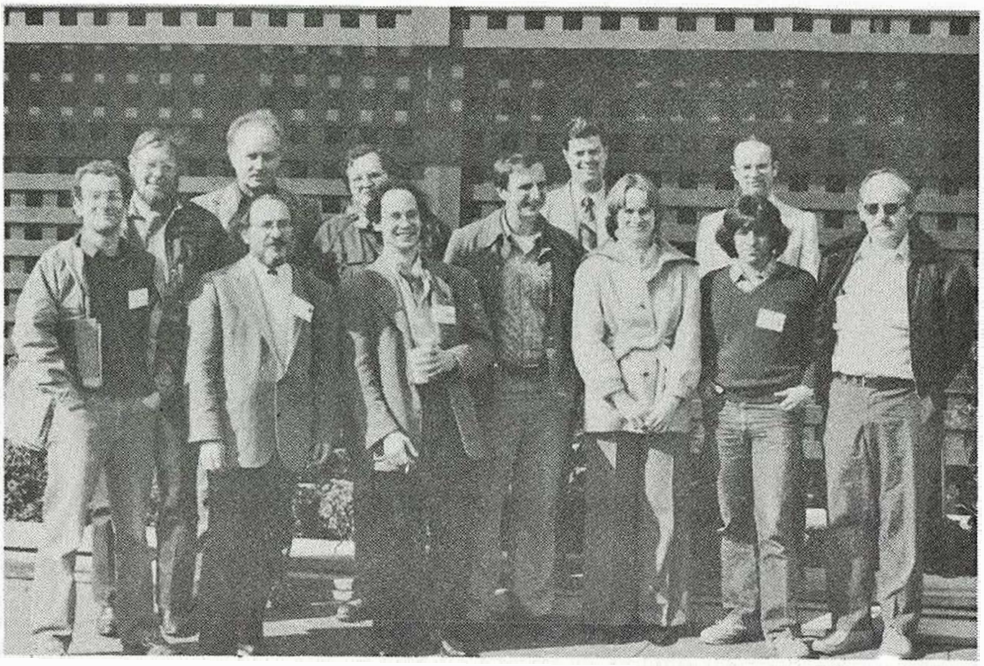
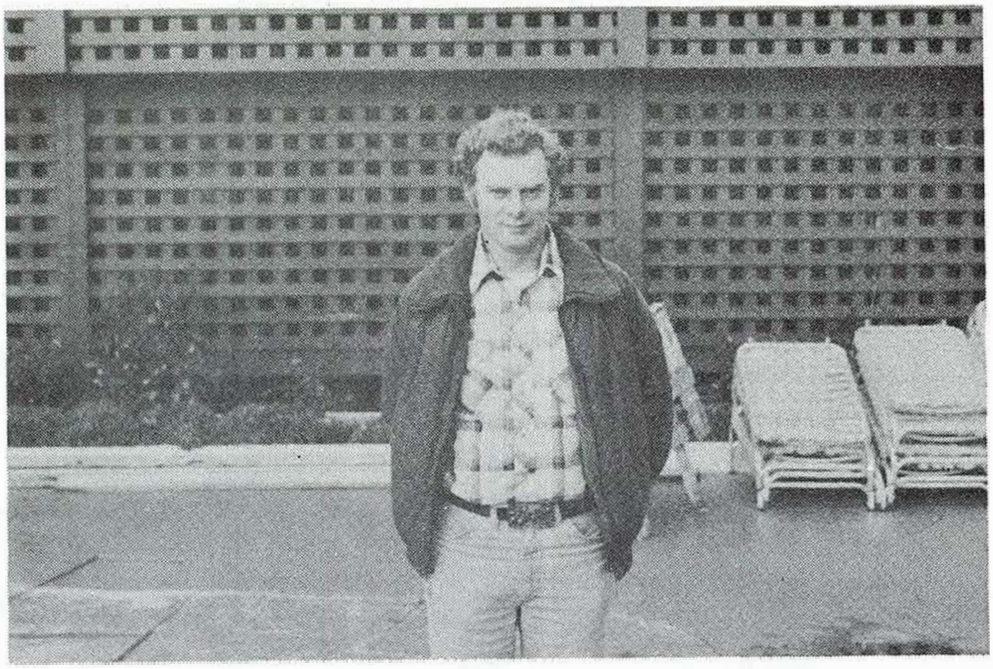
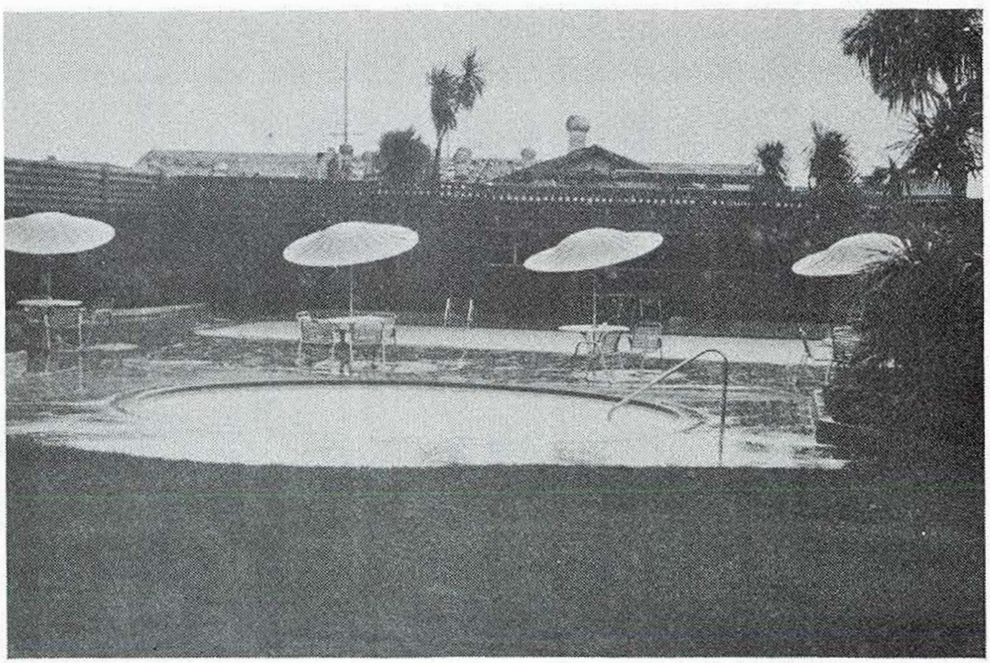


First Row, l-r: Art Stock, Pierre Charles, Willis Schaupp, Fred Hain, Ann Hajek, Jeff Millstein, D. N. Kinn. Second Row: Tony Smith, Karel Stoszek, Mike Wagner, John Harris, John Borden.

First Row, l-r: Ken Hobson, Bruce Hostetler. Second Row: Pat Akers, Jill Lownsbery, James Gasana. Third Row: Ed Holsten, Susan Tait, Tom Hofacker.



Robert Wolfe



The W. L. Freeman, Jr. wading Pool being filled by the Santa Rosa weather.

PROCEEDINGS

THIRTY-FOURTH ANNUAL WESTERN FOREST INSECT WORK CONFERENCE

SANTA ROSA, CALIFORNIA

MARCH 1-3, 1983

Executive Committee (Thirty-Fourth WFIWC)

R. Stark, Portland	Chairperson
P. Buffam, Portland	Immediate Past Chairperson
B. Hostetler, Portland	Secretary-Treasurer
S. Whitney, Victoria	Councilor (1980)
J. Laut, Fort Collins	Councilor (1981)
K. Sturgeon, McMinnville, OR	Councilor (1982)
J. Robertson, Berkeley	Program Chairperson
J. Dale, Berkeley	Local Arrangements Chairperson

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* Summary not submitted.

TECHNICAL PROGRAM

Thirty-fourth Annual West Forest Insect Work Conference
Santa Rosa, California
March 1-3, 1983

Tuesday, March 1

7:00 a.m.	Executive Committee Meeting
8:30 a.m.	Initial Business Meeting and Conference Opening
10:30 a.m.	PLENARY SESSION: Host plant - insect interactions.
	KEYNOTE SPEAKER: Ernst Von Rudloff MODERATOR: Alan Berryman
12:00 Noon	LUNCH
1:30 p.m.	PLENARY SESSION: Host plant - insect interactions (cont.)
3:30 p.m.	Informal meetings of special interest groups

Wednesday, March 2

9:00 a.m.	PLENARY WORKSHOP: Computer software packages for practical purposes MODERATOR: Kathy Sheehan
12:00 Noon	LUNCH
1:30 p.m.	DISCUSSION SESSION: Presentation and discussion of individual computer problems

Thursday, March 3

8:30 a.m. WORKSHOPS:

1. Management of forest insects
   MODERATOR: Russ Mitchell
2. Systematics/evolution of forest insects
   MODERATOR: Gerry Lanier

10:30 a.m.

WORKSHOPS:

1. Insect plant interactions: Dollar aspects in plantations and young stands
   MODERATORS: Bill Bedard and George Ferrell

2. Physiology/Biology of forest insects
   MODERATOR: John H. Borden

12:00 Noon

LUNCH

1:30 p.m.

WORKSHOPS:

1. Ecology of forest insects
   MODERATOR: Sandy Liebhold

2. Integrated pest impact assessment systems
   MODERATOR: William B. White

3:30 p.m.

Final Business Meeting

THIRTY-THIRD WESTERN FOREST INSECT WORK CONFERENCE

Minutes of the Executive Committee Meeting
Santa Rosa, California, March 1, 1983

Chairperson Stark called the meeting to order at 8:00 p.m.

Present were:

Ron Stark, Chairperson
Paul Buffam, immediate past Chairperson
Bruce Hostetler, Secretary-Treasurer
Roy Shepherd, Alternate Councilor
Karen Sturgeon, Councilor
Jackie Robertson, Program Chairperson
John Dale, local Arrangements Chairperson
Torolf Torgersen, Chairperson of Common Names Committee
John Moser, Member of Common Names Committee

Absent were Councilors John Laut and Stu Whitney. Minutes of the 1982 Executive Committee Meeting and the Treasurer's Report as of March 1, 1983, were read and approved.

Chairperson Stark reported that he had not heard from Dick Washburn to find out the status of his role as Historian of the Western Forest Insect Work Conference. This issue was tabled until such time that contact with Washburn is made.

Torgy Torgersen reported that there was a vacant seat on the Common Names Committee and that John Moser was a candidate. Moser was appointed to the vacant seat. Torgersen also proposed an open meeting of the Common Names Committee to discuss proposed common names. The meeting was approved.

Chairperson Stark reported that Skeeter Werner, Chairperson of the Ethical Practices Committee, regrets that he was unable to attend this year's Work Conference and, in his absence, has appointed Rick Johnsey as surrogate Chairperson.

The elected position of one councilor was to expire at the end of the 1983 meeting. Chairperson Stark appointed Jackie Robertson to chair a Nominating Committee along with two persons of her choice. By letter, Stu Whitney had suggested that Peter M. Hall be a nominee.

Chairperson Stark noted that invitations for the 1985 Work Conference need to be called for in the initial Business Meeting.

Registration fees of $20 for regular members and $5 for student members were approved.

Chairperson Stark initiated a discussion on the utility of the Western Forest Insect Work Conference proceedings. It was decided that feedback from the general membership was needed.

The meeting adjourned at 8:15 a.m.

THIRTY-THIRD WESTERN FOREST INSECT WORK CONFERENCE

Minutes of the Initial Business Meeting
Santa Rosa California, March 1, 1983

Chairperson Stark called the meeting to order at 8:45 a.m. and welcomed members Santa Rosa.

Minutes of the 1982 Final Business Meeting and the Treasurer's Report were read and approved. The treasurer reported a balance of $557.80 prior to the start of the Work Conference.

Minutes of the 1983 Executive Committee Meeting held just prior to the Initial Business Meeting were read.

Chairperson Stark extended a welcome to the keynote speaker, Ernst von Rudloff, and to two other visiting scientists, Pierre Charles and John Madden.

Chairperson Stark announced the following retirements:

Don Pierce, USDA Forest Service, Missoula, Montana
Don Schmiege, USDA Forest Service, Juneau, Alaska
Jerry Knopf, USDA Forest Service, Boise, Idaho
Maxine Moyer, USDA Forest Service, Ogden, Utah
Mal Furniss, USDA Forest Service, Moscow, Idaho
Randy Randall, Canadian Forestry Service, Ottawa, Ontario
Doug Miller, Canadian Forestry Service, Victoria, B.C.

Chairperson Stark also informed members of some other items of note:

Tom Payne of Texas A&M was awarded the Humboldt Foundation of Germany and is spending a year in Freiburg, Germany, conducting behavioral research.

Jackie Robertson of the USDA Forest Service, Pacific Southwest Experiment Station, has received a Superior Service Award from the Secretary of Agriculture and, also, has been appointed co-editor of the Journal of Economic Entomology.

LeRoy Kline, Oregon State Department of Forestry, received a Management Service Recognition Award from Governor Vic Atiyeh.

John Walstad, formerly forest entomologist with Weyerhauser Corportion, then associate professor at Oregon State University, has been appointed Program Manager of the Forest Intensified Research (FIR) Program at the Pacific Northwest Experiment Station in Portland.

Jeff Corneil, from Gainesville, Florida, has been appointed to the entomology staff of the Oregon State Department of Forestry. He will be located in Prineville.

Chairperson Stark asked for a moment of silence in remembrance of George R. Struble who died in 1982.

Dave Wood informed the members that Martin Birch was involved in a tragic automobile accident which resulted in a brain injury. Dave said that a fund-raising drive was being organized to help pay for hospital expenses and that members could get more details from him later.

Torgy Torgersen presented a report of the Common Names Committee of which he is chair. The following items of business were before the Committee:

1. A new common name, ponderosa pine needle miner, has been proposed for Coleotechnites ponderosae and is before the committee.

2. A new common name, western conifer seed bug, has been proposed, passed, and submitted to ESA for consideration.

3. The name black fire beetle for Melanophila acuminata was submitted to ESA. The name was protested in 1981 and published as having been rejected in a recent Bulletin of the ESA. We are in the process of determining on what grounds the name was rejected.

4. A common name change for Choristoneura occidentalis from western spruce budworm to western budworm was brought before the membership at last year's meeting. After some discussion the proposal was tabled to await developments concerning possible taxonomic revisions.

5. The Southern Forest Insect Work Conference Committee on Common Names has suggested that we consider common names for Ips grandicollis and Ips calligraphus. Neither species now has a common name.

6. With the resignation of Karel Stoszek, there is a vacant seat on the Committee. John Moser, chairperson of the Common Names Committee of the Southern Forest Insect Work Conference, is a candidate for this seat.

7. An open meeting of the Committee will be held at 8 p.m. on Tuesday, March 1, in the Burgundy Room. We will discuss the desireability and appropriateness of names before the Committee.

Chairperson Stark reminded members of several professional meetings that may be of interest:

-Southern Forest Insect Work Conference, August 8-12, 1983, Biloxi, Mississippi
-Society of American Foresters, October 16-19, 1983, Portland, Oregon
-Pacific Branch of ESA, June 21-24, 1983, Spokane, Washington

Kareen Sturgeon informed members that copies of the book "Bark Beetles of North American Conifers" edited by her and Jeff Mitton would be available at a 20% discount during the conference.

Chairperson Stark called for discussion concerning the utility of the work conference proceedings and whether or not any changes were recommended. Roy Shepherd reported that eight of ten people he polled in Canada recommended no change. John Foltz said that he finds the proceedings useful and encouraged continuation as is.

Bruce Hostetler reported that five copies of 1982 Proceedings were available at $3.00 per copy.

John Bordon asked if a reprint table was to be set up. Chairperson Stark indicated that, due to an oversight, there was none, and that a note should be made to ensure one is available at next year's meeting.

Chairperson Stark requested members to be thinking about invitations for the 1985 meeting and that it may be about time for a conference to be held in the Colorado area.

Meeting was adjourned at 9:20 a.m.

TREASURER'S REPORT

Thirty-third Western Forest Insect Work Conference
Santa Rosa, California, February 28, 1983

Balance on hand March 4, 1982	(+)	$1,416.10
Expenses:		
1982 Proceedings Publication	(-)	$ 563.12
Postage	(-)	$ 170.50
Envelopes	(-)	$ 23.20
Income:		
Credit Union Membership Fee Refund	(+)	$ 5.00
Interest	(+)	$ 46.41
Balance on hand December 31, 1982	(+)	$ 710.69
Expenses:		
Conference arrangements and supplies	(-)	$ 154.44
Bank service charge	(-)	$ 3.00
Income:		
Interest	(+)	$ 4.55
Balance on hand February 28, 1983	(+)	$ 557.80

PLENARY SESSION: HOST PLANT/INSECT INTERACTIONS

Moderator: Alan A. Berryman

Participants: Ernst von Rudloff, Davey Rhoades, Fred Hain, Mike Wagner, Paul Svihra, Ross Miller, Tim Paine, Kareen Sturgeon, Marc Linit, Roy Shepherd, Fred Stephen, Karel Stoszek, Russ Mitchell, Sceeter Werner (by proxy).

INTRODUCTORY COMMENTS

Alan A. Berryman

In the last few years a tremendous amount of interest has been generated on the role of the host plant in the population dynamics of forest insects. Landmark symposia were held at the 1980 ESA Meeting in Atlanta and at the 1981 IUFRO Conference in Siberia, and followup symposia are being organized in West Germany and Alberta this year.

In preparing this forum, I contacted 25 scientists who are conducting research on various aspects of insect interactions with forest trees and there are many more that I know of scattered throughout the world. As a result of this expanded interest we are gradually learning that forest trees are not passive spectators to the assaults of insects but, rather, have evolved complex responses in their own defense. Ever since the work of Robbie Reid in the mid 60's, we have known that conifers mobilize defensive compounds in response to bark beetle attack. More recently, with the work of Rex Cates, Davey Rhoades, Jack Schultz, and others, forest trees have been shown to react in a similar way to defoliating insects, even to the point of trees shifting defensive chemicals around in an unpredictable manner and, perhaps, trees communicating the presence of insect feeding to each other.

In organizing this forum, I have attempted to bring together some of the people who have new insights and ideas on plant-insect interactions. We hope to present these ideas in an informal manner in order to stimulate discussion from the floor. Our aim is to generate an awareness of the complex and dynamic nature of interactions between trees and insects and to provide ideas on how this information can be used to prevent or reduce insect damage to the forest.

SEASONAL VARIATION IN THE LEAF-OIL TERPENES OF CONIFERS AND POSSIBLE IMPLICATIONS IN HOST-INSECT INTERACTIONS[1/]

by

Ernst von Rudloff, Principal Research Officer
Prairie Regional Laboratory, National Research Council
Saskatoon, Saskatchewan, Canada

1/Work leading to this publication was funded by the USDA Forest Service Canada/United States Spruce Budworms Program, Washington, DC.

Insects, being highly affected by chemical signals, may be influenced strongly in their choice of individual host plants by phenotypic differences of volatile compounds stored and released by the plant (Dethiér 1970). Having gained experience especially in the volatile-oil compositions of conifers, I will restrict this discussion to those volatile conifer components that could influence host choice by insects through their olfactory reactions. Although there are some reports in the literature (see review by Hanover 1975) that implicate several terpenes found in conifer foliage with host-insect interactions, good correlation between terpene composition and either insect attraction or repellency appears to be lacking. In part, this may be the result of the complexity of the volatile oils found in conifer foliage (von Rudloff 1975a). Another reason could be that the actual terpene composition at the time of host-insect interaction has not been examined. Thus, in addition to considerations of the behavioral aspects of, for example, phytophagous insects (Dethiér 1953, 1970; Schoonhoven 1978) or physiological reactions of the insect to the host's chemicals (Schoonhoven 1978, Simpson 1976), the inherent and the seasonal variation in the volatile-oil composition must be taken into account. To complicate matters, the chirality of the terpenes and synergism with insect pheromones must be considered as well (Silverstein and Young 1976, Vité et al. 1978, Wood 1973).

In our chemosystematic studies of northern North American conifer species, we have found most leaf oils to be composed of 5 to 10 major components and from 20 to over 100 minor and trace components (von Rudloff 1975a). These comprise mainly mono- and sesequiterpenes, but some volatile diterpenes and nonterpenoid hydrocarbons, alcohols, aldehydes, ketones, esters, or aromatic ethers may also be found. Some biogenetic relationships amongst the monoterpenes as deduced from co-occurrence in conifers were reported by Zavarin (1970) and von Rudloff (1975a). We established that the qualitative and quantitative leaf-oil composition of a given conifer is constant in foliage samples collected in the fall and winter, and as in oleoresin terpenes (Hanover 1975, Squillace 1976), strong genetic control was indicated (von Rudloff 1975a, von Rudloff and Rehfeldt 1980). During the dormant season, variation within the crown of a tree is small, although we did encounter quantitative gradients in a few older Douglas-fir, Engelmann spruce, and mountain hemlock trees. Scientific names for conifers mentioned in this paper are listed in table 1.

Table 1

Quantitative variability of the leaf-oil terpene compositions of the dormant season in various northern North American conifer species.

Conifer species	Intra-population variability	Inter-population variability		Geographical variability	References*
A. TRUE FIRS (Abies):					
Coastal alpine (A. lasiocarpa)	High	Low	Low	High in areas of overlap	1,2,3
Interior alpine (A. bifolia)	High	Med.	Med.	High in areas of overlap	
Balsam (A. balsamea)	Med.	Med.		East-west cline	
Pacific silver (A. amabilis)	High	Med.	?	Any; northern = southern	1,4
Grand (A. grandis)	High	Low		Coastal = interior (introgression with white fir)	5
B. DOUGLAS-FIR (Pseudotsuga):					
Coastal (var. menziesii)	Med	High		Two types and intermediates; high in areas of overlap	1,6-9
Interior (var. glauca)	Low	Low		Two minor types, northern = southern	
C. SPRUCES (Picea):					
Black (P. mariana)	Low	Low	Very low	Eastern = western introgression	1,10,11
Red	Low	Low	?		1
Sitka (P. sitchensis)	High	Low	?	Minor introgression	1,12

Table 1 (continued)

Conifer species	Intra-population variability	Inter-population variability		Geographical variability	References*
White (*P. glauca*)	Low	Med.		East-west cline; Yukon, more variable introgression	1,10,11,13
Engelmann (*P. engelmannii*)	High	High	High		1,11,14
Blue (*P. pungens*)	High	?	?		1
D. PINES (*Pinus*):					
Shore (*P. contorta* var. *contorta*)	Low	Low		Northern = southern; high in areas of overlap	15,16
Lodgepole (var. *latifolia*)	High	High	High;	many types	1,11
Jack (*P. banksiana*)	Med.	Med.		Introgression; two major and minor types	1,17
Ponderosa (*P. ponderosa*)	Low	Low		Minor; eastern = western	1,11
Western white (*P. monticola*)	High	Low		Coastal = interior	1,18
E. CEDARS (*Thuja*):					
Western red (*T. plicata*)	Low	Low		coastal = interior	1,19
Eastern white	Low	?		?	1
F. HEMLOCK (*Tsuga*):					
Western (*T. heterophylla*)	Med.	Low		Coastal = interior	1,20
Mountain (*T. mertensiana*)	High	Low		Coastal = interior	1,11
Eastern (*T. canadensis*)	Med.	?	?		1

*References to table 1:

1. von Rudloff, E. 1975. Biochem. System. and Ecol. 2, 131-167.
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11. von Rudloff, E. In preparation.
12. von Rudloff, E. 1977. Phytochem. 17, 127-130.
13. von Rudloff, E., E. T. Oswald, and E. Nyland. 1981. Can. For. Serv. Res. Note 1, (No. 4), 32-34.
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16. Pauly, G., and E. von Rudloff. 1971. Ibid. 49, 1201-1210.
17. Lapp, M. S., and E. von Rudloff. 1982. In press.
18. Hunt, R. S., and E. von Rudloff. 1977. For. Sci. 23, 507-516.
19. von Rudloff, E., and M. S. Lapp. 1979. Can. J. Bot. 57, 476-479.
20. von Rudloff, E. 1975. Ibid. 53, 933-939.

Reproducibility depends on foliage sample size, 30 to 100 g of leaves giving satisfactory results in most species. As the sample size is decreased, so variability within the crown, or even along larger branches, is found to increase, and the quantitative variation from one needle to another may be relatively high. Pine needles from the same fascicle appear to have the same quantitative composition, however (von Rudloff 1969). Larger foliage samples from different aspects (north, east, south, and west) of the crown of a white spruce tree did not show differences outside of the experimental error (von Rudloff 1967). For chemosystematic studies, 5- to 50-year-old trees provided the most consistent data, individual trees providing the same quantitative composition year after year. In some younger seedlings, juvenile effects were apparent, and very old trees are, of course, difficult to sample.

We have examined geographic variation in the leaf-oil terpene composition of most northern North American conifer species and varieties, and the intra- and interpopulational variability is summarized in table 1. These results apply only to the foliage of the dormant season when the composition is under genetic control. Even then, the diversity of the variability within species of the same genera is astonishingly large.

When the winter leaf-oil composition of a given conifer species are compared with host-insect attraction data from the literature, correlations with major terpenes are far from convincing. A somewhat better situation pertains to the monoterpenes of cortical oleoresins and bark beetles (Billings et al. 1976, Hanover 1975, Heikkenen and Hrutfiord 1965, Rudinsky 1966, Smith 1966, Wood 1973), pine weevils (Wilkinson 1980), and wood wasps (Simpson 1976), but here, too, some contradictions appear (Coyne and Critchfield 1974, Pitman 1969). With the leaf oils, an answer may be that the terpene compositions differ markedly at the time of insect attack from those of the dormant season. Our studies of seasonal variation of the leaf, twig, and bud terpenes of white, black, and blue spruce (von Rudloff 1972, 1975b, 1975c) and balsam fir (von Rudloff and Granat 1982), and those by Hrutfiord et al. (1974) on Sitka spruce, by Maarse and Kepner (1970) on coastal Douglas-fir, and by Zavarin et al. (1971) on ponderosa pine confirm this view. Large quantitative changes occur in the new leaves from budburst to the end of leaf elongation, i.e., at the time of maximum insect activity, and in some species also in the buds well before budburst. The older leaves show far less variation and, in some species, their composition is similar to that in the dormant season.

Rasmussen (1970) has demonstrated release of isoprene from the leaves of many plants and trees, including conifers, in early summer. Our white spruce data indicate the presence of such hemiterpenes in the steam-distilled oils of young summer leaves. It is thus in the new shoots and young leaves that major quantitative, and possibly also qualitative changes, occur, and these will greatly affect the composition of the atmosphere surrounding the foliage of conifers at a time when insects are most active. Here the findings of Bernard-Dagen et al. (1979) may also be of interest. These authors found that the most active

synthesis of monoterpenes in the needles of the maritime pine, Pinus pinaster, occurs in the epithelial cells of the resin ducts, and that this activity is temporal along the length of the needle. In contrast, the sesquiterpenes are synthesized in the whole needle continuously during the entire growing season. We found in the bud oil of blue spruce a transient diterpene with maximum concentration just before budburst (von Rudloff 1975c). Such results indicate the extent of the chemical and biosynthetic complexity during late spring and early summer, and this justifies a reevaluation of the problems in host-insect interactions with regard to the foliage terpene composition.

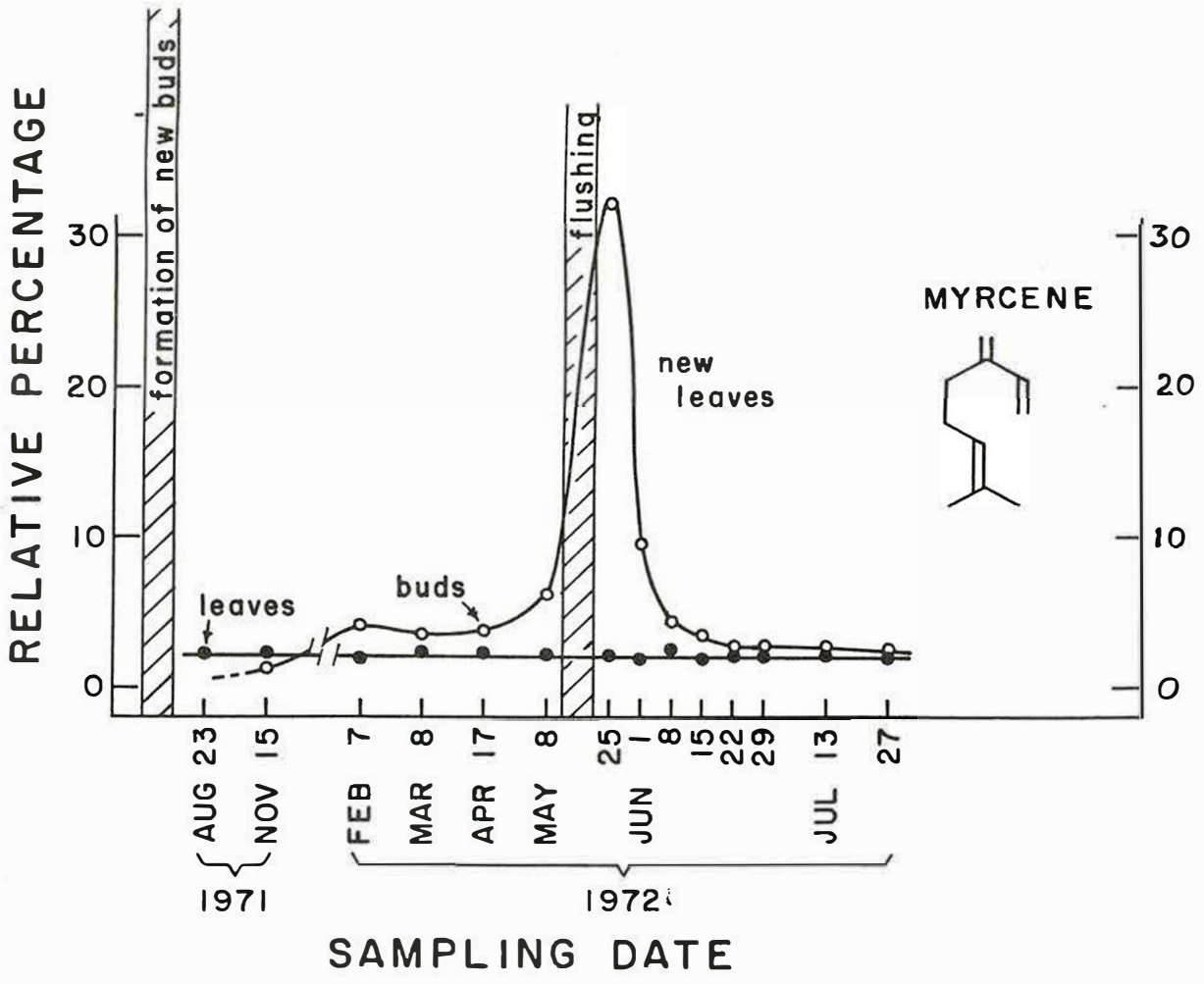
Considering the low degree of variation of the fall and winter leaf oil of black spruce (see table 1), one might expect only slow and regular changes in the new growth after budburst. This we did find with the camphene group of terpenes, α- and β-pinene, and limonene.

Myrcene, however, changed from less than 4 percent in the buds to over 30 percent just after budburst, only to drop back again to 5 percent and less 2 weeks later (see fig. 1). Car-3-ene, which is the main constituent of the bud oil (about 50 percent), dropped rapidly to less than 1 percent during this time (von Rudloff 1975b). Thus, just before and after budburst, reversals in the relative amounts of some terpenes take place in young tissues. The older leaves, in contrast, show only minor changes in all terpene percentages. Blue spruce, which has a high tree-to-tree variability in the leaf oil of the dormant season, showed major changes in the α- and β-pinene, car-3-ene, myrcene, and limonene percentages just after budburst. The camphene group increased steadily, as was found in black spruce (von Rudloff 1975c), which may indicate a different biosynthetic control. Similar results were obtained with white spruce, except that car-3-ene was a minor or trace component at all times (von Rudloff 1972). Balsam fir, which is also quite a variable species (see table 1), showed surprisingly little seasonal variation in the new shoots (von Rudloff and Granat 1982). The seasonal changes in neighboring trees of the same species were similar, but some time shifts as a result of differences in budburst dates appear to exist. These findings may have major implications in host-insect interactions, especially when late spring and early summer are times of maximum activity of the insects as well.

Heikkenen and Hrutfiord (1965), as well as Rudinsky (1966), have shown that α- and β-pinene content of Douglas-fir oleoresin has major implications in attraction of scolytid bark beetles. A reversal of the ratio of these two terpene isomers could result in deterrency rather than attraction. Our data show that such reversals of ratios are possible in the new leaves shortly after budburst, especially in coastal Douglas-fir with the type C (low-percentage β-pinene, high-percentage terpinene group; von Rudloff 1973, 1975a) leaf-oil terpene pattern. This could apply to more than a pair of terpenes like α- and β-pinene and resembles the situation with insect pheromones where multicomponent systems appear to be most effective (Silverstein and Young 1976, Steck et al. 1982, Underhill et al. 1977).

Recently, McDonald (1981) reported on differential defoliation of neighboring Douglas-fir trees by western spruce budworm in Montana, green trees occurring next to heavily defoliated ones. Exploring many possible factors that could explain this phenotypic variation, he states, "If the green trees derive from any integration with the chemical message system of the insect, considerable knowledge would have to be gained even before breeding and testing procedures can be planned." From the above data, it follows that a promising point to start with would be the study of seasonal variation of the foliage terpenes and other volatile compounds in such neighboring trees. Just as there is a difference in the time of budburst in individual trees of a given stand, so one can expect major differences in the relative amounts of volatile foliage components that may act as attractants or repellents at this time of maximum biosynthetic activity. Western spruce budworm infestations have occurred also in central British Columbia during recent years (Shepherd et al. 1977), and what may be of particular interest from the point of view of leaf-oil terpene compositions is that many of the severe attacks occurred in areas where the two Douglas-fir varieties overlap and intermix. At Mission Pass, elevational banding of defoliated trees was observed. Last fall, we collected foliage samples from this area from five trees each at about 500-foot-elevation intervals. We found some segregation into coastal and intermediate terpene patterns, but our sampling density was too low to permit any definite correlations. At Mission Pass and further west in the D'Arcy-Pemberton area, many trees had the type C terpene pattern (von Rudloff 1973). Our limited data would indicate that in such trees reversal of α- and β-pinene ratios, for example, could occur as the new leaves mature. But much more sampling at the time of maximum insect activity would have to be done to determine possible correlations. Also, the atmosphere surrounding susceptible and resistant trees would have to be analyzed. The experimental procedures for such detailed investigations are available (Adams et al. 1979; Evans et al. 1982; Rasmussen and Jones 1973; von Rudloff 1975a,b,c, 1969). A serious complication may be the tendency of the more reactive terpenes to autoxidize. It could well be that some insects interact with such autoxidation products rather than the parent terpene. Adams and Hagerman (1977) have reported in detail on diurnal variations in the leaf-oil terpenes of the Rocky Mountain juniper. We have bypassed such potential variation in our seasonal-variation studies by sampling at the same time of day. Vité et al. (1978), as well as Silverstein and Young (1976), stress the importance of optical isomers in insect pheromones, and Manville (Rogers et al. 1974) in juvenile hormone analogs. Hence, determination of the chirality of terpenes would also enter into the experimental requirements. This presents no problem per se, but requires much more than the milligram amounts of oil which suffice for gas-chromatographic, mass-spectrometric analysis (Adams et al. 1979). Our chemosystematic studies have shown that once the optical rotations of the terpenes found in a given conifer species have been determined, these can be applied in other work concerning this species, provided no hybrids are encountered.

Figure 1. Seasonal variation of the relative amounts of myrcene in black spruce foliage.



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OFFENSIVE-DEFENSIVE INTERACTIONS BETWEEN HERBIVORES AND PLANTS

David F. Rhoades

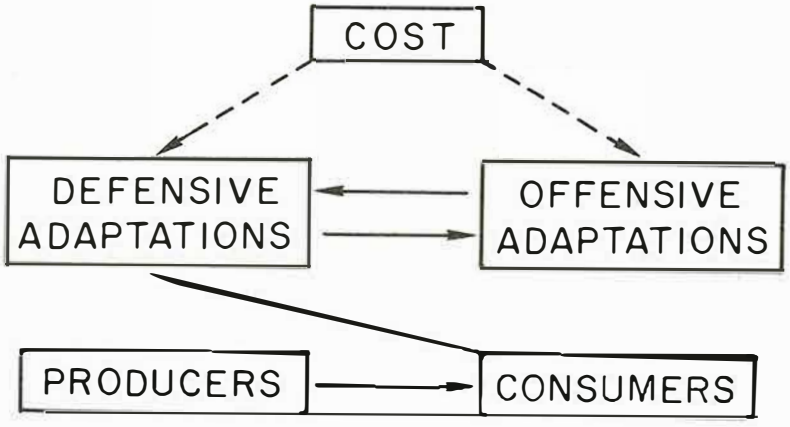

Figure 1. Offensive-defensive coevolution between consumers and producers.

The existence of producer organisms has led to the evolution of consumers (Figure 1). Predation by consumers on producers has led to the evolution of defensive adaptations in producers which, in turn, select for offensive counteradaptations in consumers that tend to reduce the effectiveness of the prey defenses. Offensive adaptations of consumers select for amplified prey defenses. The positive feed-back loop between defense and offense is probably under the controlling influence of metabolic cost, since energy and nutrients allocated to defense (see Rhoades, 1979; Mooney and Gulmon, 1982) or offense are not available to meet other requirements of organisms (Figure 1). For each defensive adaptation in producers we can therefore expect to find complementary offensive adaptations in consumers and vice-versa. Known and possible defensive adaptations of plants against herbivores and their complementary known and possible offensive adaptations in herbivores are displayed in Figure 2 (see Rhoades, 1983a). For each defensive attribute of plants, alternative offensive tactics in herbivores are known or can be postulated.

Against constitutive defenses (1), herbivores have evolved, on one hand, detoxification and tolerance mechanisms (2), and on the other, the ability to preferentially attack tissues with low levels of defensive substances or plants in a vulnerable condition due to stress (3). The existence of attack-induced defensive responses of plants (4) and the plasticity of plant defensive capability which this demonstrates, suggests that herbivores may have evolved adaptations to suppress inducible defenses (5) and even to induce decreased levels of defensive substances in plants (6). Although there is no direct evidence for differential recognition of mechanical and herbivore damage, recognition of, and acquired immunity against, particular herbivore species by plants

(7), such adaptations would be advantageous. Analagous phenomena are known in plant pathology. If recognition and acquired immunity are components of plant defensive adaptation we can expect some herbivores to display mechanisms to suppress recognition of attack in plants (8). Others may restrict their attack to naive plants that have not been immunized by recent attack and then emigrate when or before they are recognized and defensive responses are induced (9). Advanced warning of attack (10) would be highly advantageous to plants. There is limited evidence that unattacked plants can detect and defensively respond to airborne substances emitted by nearby unattacked plants (Rhoades, 1983b; J. C. Schultz, this session). If pheromonal communication between plants is common we can expect some herbivores to block the release or action of the active substance (11). Others may emit signals that disrupt communication or that cause an inappropriate response in the plant (12). These alternative offensive tactics of herbivores possibly constitute two discrete attack strategies. Phytophagous insects with population densities that greatly vary in space and time may be Opportunistic, whereas those with low, relatively constant populations may be Stealthy (Figure 2, Table I). Phase changes in herbivores (e.g. locusts, African armyworm, larch budmoth) may be due to transition from one strategy to the other.

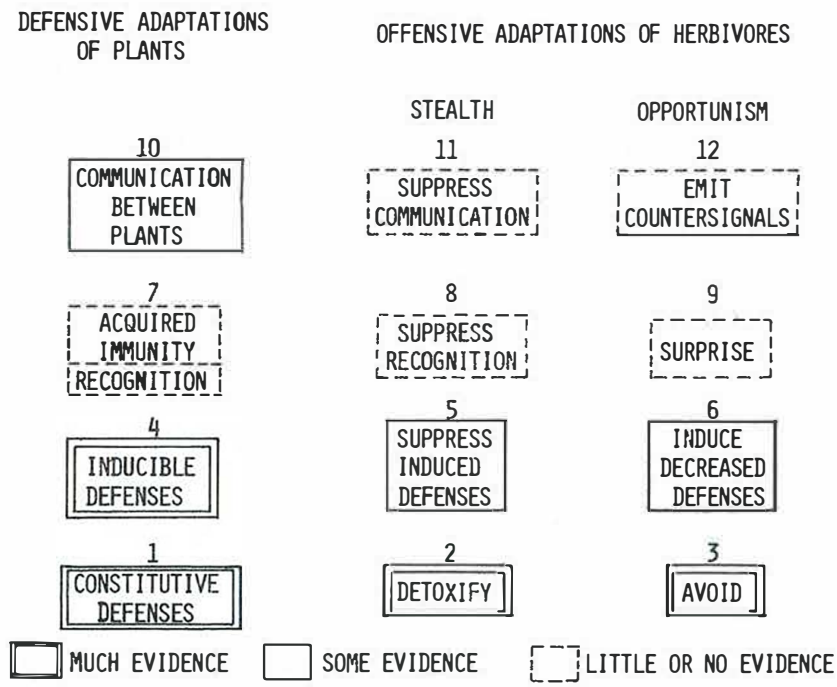

Figure 2. Defensive adaptations of plants and complementary offensive adaptations of herbivores.

Table I. Expected correlates of Stealthy and Opportunistic herbivore species in addition to those of Figure 2.

Stealthy	Opportunistic
Stable populations	Variable populations
Solitary	Gregarious
Territorial	Colonial
Single eggs	Clustered eggs
Non-migratory	Migratory

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REACTIONS OF CONIFERS TO STEM WOUNDING

F. P. Hain

The response of a conifer to stem invasion is a dynamic process that consists of three components: 1) wound cleaning by the resin canal system, 2) containment of the infection by the hypersensitive response, and 3) wound healing by the formation of wound periderm. Xylem tissue is frequently rendered non-conductive by the build-up of terpenes and other compounds frequently associated with normal heartwood. In order for a tree to successfully resist or tolerate an attack, the entire response process must be completed with minimum interference from the invading organisms. Depending upon the triggering agent, particular components of the response system may be of primary importance in a successful host defense.

INDUCIBLE DEFENSES IN PONDEROSA PINE

Michael R. Wagner

There has been much interest in recent years in the mechanisms of plant defense against herbivores. It was theorized some time ago that a cost-effective approach to plant defense (from the plant's viewpoint) would be to "turn on" defenses only when actually necessary to defend against a herbivore. There are numerous examples appearing in recent literature that suggest that just such inducible or immune responses exists in plants. Working with ponderosa pine seedlings, we have found that two candidate defensive compounds, penols and tannins, are produced in larger quantities as a result of mechanical defoliation. The protein content of foliage also increased as a result of defoliation. We hope to evaluate further how quickly these changes occur and whether "induced" foliage is a poorer food source that "non-induced" foliage.

We have also evaluated the effect of host physiological condition on an early-season defoliator (western spruce budworm). We found very little differences in the insects feeding efficiency, growth rate and final pupal weight on hosts of different vigor ratings (Waring et al method). We plan to continue several research projects relating to host vigor and its influence on insect herbivores.

DEFENSE COMMUNICATION AMONG TREES

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A report by David Rhoades (University of Washington) a year ago suggested that uninfested alder trees growing near to alders infested and damaged by western tent caterpillar underwent some kind of change which reduced the value of their leaves as caterpillar food. Davey said that he thought that the uninfested trees might be receiving some airborne cue from the damaged trees which stimulated a chemical or physiological change.

At Dartmouth, Ian Baldwin and I thought we might test this hypothesis under controlled conditions in the laboratory. We performed several experiments in which we damaged the leaves of 15 potted sugar maple or 15 poplar seedlings we had placed in controlled air-flow environmental chambers; we tore 2 of the 20-25 leaves on each plant in half. A second set of 15 seedlings were also placed in the same chamber, but were not damaged. A third set of potted trees were placed in another chamber, with its own air supply; these trees were not damaged. At intervals, we removed several whole trees from each group and analysed their leaves for total phenolics, condensed and hydrolysible tannins, and protein binding. We found that the undamaged leaves of individual trees we had damaged (torn 2 leaves) exhibited significantly elevated total phenolic and tannin concentrations when compared with controls. Moreover, the undamaged trees in the same chamber with damaged trees exhibited similar changes. Like the damaged trees, their leaves showed significantly elevated phenolic contents by 38-52 hours after their neighbors were damaged. For all trees, these responses waned by 75 hours.

We conclude from these results that juvenile trees growing in the presence of (sharing an airspace with) other individuals of the same species which lose as little as 7% of their leaf area (the amount removed in tearing) are stimulated to alter physiological and biochemical pathways. These alterations could reduce susceptibility to subsequent herbivore attack. Since all plants were potted, the stimulatory "cue" must be airborne, and is probably a volatile compound release by damaged plant tissues.

It has been suggested by Rhoades that this phenomenon, if general, could contribute to the apparent synchrony in population dynamics of outbreak defoliators over wide areas. In any event, bringing many trees in a stand into defensive synchrony could explain the nearly instantaneous crash of outbreaks over large areas. It certainly would seem to be of advantage to individual trees to "gear up" for defense when adjacent trees are defoliated; metabolic "savings" might be achieved over longer-lived or continuous defenses. Perhaps the factor which "cues" the undamaged leaves in an induced tree to respond when other leaves are damaged is also airborne.

RESPONSE OF *SCOLYTUS MULTISTRIATUS* TO ELMS INFECTED BY *CERATOCYSTIS ULMI*

Pavel Svihra

The successful compartmentalization of elm tissues infected by *C. ulmi* also prevents the colonization of these tissues by the bark beetle vector *S. multistriatus*. If the defense mechanisms of an elm tree are slow to respond to *C. ulmi* the beetle will colonize those branches, or branch portions, which are dying or have been killed by the fungus. Once the Dutch elm disease fungus and its beetle vector are both established beneath the bark, the host elm dies rapidly. How elms contain or repel the fungus and the beetle attack by means of the internal compartmentalization is discussed.

ENERGY AND THE WOUND RESPONSE OF CONIFERS

Ross Miller

Monoterpene synthesis in conifers is a metabolically expensive process. Not only are 18 ATPs required for the synthesis of a single monoterpene molecule, but an additional 72 ATPs are lost to the tree when acetyl-CoA is rerouted from the Kreb's cycle to the mevalonic acid pathway that ultimately yields the monoterpene product. A total of 90 ATPs is thus lost to the tree for every monoterpene produced [1].

In hopes of clarifying the link between monoterpene synthesis in the wound response of lodgepole pine and its energy resources, I have quantified monoterpene and carbohydrate titres in fungus-induced (*Ceratocystis clavigerum*) lesions in the phloem over time. Results thus far derived show that there is a general 30% decrease in total soluble sugars in lesion phloem after a five day period. This reduction is mostly due to decreases in non-reducing sugars, as titres of reducing sugars decrease but 10% during this time. Furthermore, the greatest decrease in sugars appears within 24-36 hours following inoculation of the pathogen, and then levels off. Starch titres do not change significantly during this period. The rapid increase in monoterpene titres in the lesion area is much greater than can be accounted for by sugar mediated monoterpene synthesis within the lesion. I suspect that xylem and phloem translocation of resinous material contributes greatly in raising monoterpene titres to their observed level. I also suspect that starch reserves, which apparently are not utilized during this type of short term response, are later depleted to rebuild the chemical defenses of the tree and maintain basic metabolic processes. This may lead to a generally lower overall "vigor" during subsequent time intervals and greater susceptibility to bark beetle attack.

[1] Wright, L. C., A. A. Berryman, and S. Gurusiddaiah. Can. Ent. 111: 1255-1262 (1979).

WOUND RESPONSES OF CONIFERS UNDER STRESS

Timothy D. Paine

Conifers respond to insect/fungal invasion by producing a hypersensitive tissue response around the invading organism. This tissue response is modified by the physiological stress of the tree. We inoculated three different diameter class loblolly pine trees in an even-age stand, based on the assumption that smaller trees were more stressed than larger trees of the same age. Hypersensitive lesions produced in response to inoculation were subsequently sampled.

Two studies were completed. The first study was designed to determine if trees responded differently at breast height, at 6.10 m., or 9.14 m up the stem. Trees on a wet site and a dry site were inoculated. There were no differences in response at the three inoculation heights, but the less stressed trees responded with larger lesions than did the smaller trees. Also, trees on the drier site responded greater than did trees on the wetter site.

The same areas and size class trees were used for the second study. We examined the change in response with increasing density of inoculation. However, there were no differences in response between any density with the extremes at 1 inoculation/928 cm^2 and 32 inoculations/928 cm^2. Again, there were differences in response with tree stress and differences in site.

DETOXIFICATION AND HOST SELECTION

Kareen Sturgeon

Kareen Sturgeon and Jackie Robertson found significantly lower enzymatic activity of mixed-function-oxidases (MFO's) in mountain pine beetles inhabiting ponderosa pines in an area where the beetles are usually found in lodgepole pine. MFO's catalyze a series of reactions by which lipophilic compounds, such as host-produced terpenes, are made hydrophilic. The authors speculated that beetles in the alternate host may not have as great a capacity to detoxify host toxins or to produce pheromones as beetles that are utilizing their usual host.

EFFECTS OF THE PINEWOOD NEMATODE ON ITS HOST

Marc J. Linit

The pinewood nematode, Busaphelenchus xylophilus, has been recovered from the xylem tissue of wilted pines throughout the United States. The nematode is believed to enter healthy trees through feeding wounds made by insect vectors. Several hypotheses regarding the effect of the nematode on its host tree have been developed by scientists at the University of Missouri-Columbia and the University of Missouri-St. Louis.

Toxic substances have been isolated from B. xylophilus - infested Scotch pine. The nematode or associated microorganisms may be involved in the production of a phytotoxic material resulting in tree death. Tree mortality leads to insect colonization and allows continued transmission of the disease. Phytotoxic materials may be synthesized by pathogens, or through the metabolism of host tree resin components to toxic end products or precursors for synthesis of a phytotoxin.

It appears that the component materials of the phytotoxin are derived from resin components of the host tree suggesting that the toxin is synthesized by the tree. We have speculated that the toxin represents the end product of nematode detoxification of a phytoalexic compound. The nematode population builds rapidly following its introduction and spreads rapidly throughout the tree. As a result, the phytoalexic response would be stimulated at several sites within the tree. The tree would accumulate phytotoxic end products in response to the spread of the nematode population and tree mortality would occur.

PHENOLOGICAL INTERACTIONS BETWEEN DOUGLAS-FIR BUDS AND EMERGING SECOND INSTAR WESTERN SPRUCE BUDWORM

Roy F. Shepherd

A technique was described to relate seasonal development of buds of Douglas-fir to larval emergence and survival of western spruce budworm. Losses of larvae due to asynchrony of emergence and bud swelling and the reduced protection of the bud following flush was discussed and related to tree, site and yearly weather differences.

EFFECT OF DEFOLIATION ON PLANT DEFENSE AND SURVIVAL

Richard A. Werner.

Periodic outbreaks of aspen and birch defoliators denude thousands of hectares of hardwood and browse shrub stands throughout Alaska. These outbreaks appear cyclic and occur every 10 to 15 years. A five year study was completed in 1980 to determine the impact of repeated insect defoliation on shrub growth and survival. Fifteen year old aspen and birch stands were manually defoliated as follows: 100%, 50%, and nondefoliated control trees. Stands were defoliated for either 1, 2, or 3 years and either early or late in the growing season.

Aspen and birch sustained severe reduction in radial and terminal growth following two or more years of 100% defoliation. Those trees with late season defoliation sustained greater loss than early season defoliated trees. Birch showed greater growth loss than aspen. Tree mortality occurred one year after the third consecutive 100% defoliation in both aspen and birch. When these trees were partially defoliated (50%), growth was reduced but to a lesser amount than 100% defoliated trees.

Three consecutive years of 50% defoliation appeared to stimulate terminal growth and leaf biomass production in both aspen and birch one year following the third defoliation. Biomass production in early 50% defoliated trees increased above that of control trees within two years after trees were last defoliated.

Nitrogen levels did not change in trees defoliated for one year but levels decreased each consecutive year therafter when trees were defoliated for two and three years in succession. Nitrogen levels returned to comparable levels of control trees one year following defoliation for 50% defoliated trees and two years for 100% defoliated trees. Nitrogen levels were still higher in defoliated trees than control trees five years after the last defoliation (100%). Frass collected from larvae feeding on the test trees showed decreased levels of nitrogen but these levels did not decrease as much or as rapidily as leaf nitrogen levels following defoliation. Nitrogen

leached from insect frass at a relatively slow rate. This could account for the increase in foliar nitrogen levels following the last defoliation; i. e., nitrogen leached from frass was utilized by the defoliated trees.

Total phenolics of leaves from defoliated trees increased in relation to the amount of defoliation. Total phenolics were higher in trees defoliated 100% than 50% for two and three consecutive years. Phenolics were also higher in trees defoliated late in the growing season. Phenolic levels remained at high levels for 2 to 3 years after the last defoliation. There was a direct relationship between phenolics level and number of years of successive defoliation.

The amount of defoliation per tree and the amount of successive defoliation over a period of years determine whether defoliation is advantages to a forest stand.

EFFECT OF THE HOST ON SOUTHERN PINE BEETLES

Timothy D. Paine

We were able to demonstrate in the earlier presentation that the defense responses of conifers are effected by plant stress. This could have important implications on the colonization and reproductive success of bark beetles. We have completed a cooperative study with T. E. Nebeker's group of Mississippi State University and J. R. Bridges at the Southern Forest Experiment Station on the impact of host resistance on southern pine beetle population dynamics. Indices of host defense mechanisms were evaluated in trees ahead of an expanding beetle infestation including hypersensitive size and terpene content, tree growth measurements, and host resin characteristics. Beetle attack density, reemergence density, gallery length, oviposition, egg and early instar survival, and progeny adult emergence were determined from those same trees after infestation. Preliminary analysis of the data suggests that parameters of resistance can be correlated with insect population dynamics. Incorporation of this information into the Arkansas southern pine beetle simulation model may provide ways to characterize the resistance of stands of trees and assess the impact of a resistant stand on a population of beetles. This will help refine the predictions of infestation growth.

PLANT RESPONSES AND PEST OUTBREAKS

Alan A. Berryman

Werner Baltensweiler and his associates in Switzerland have for many years been trying to identify the causes of cyclic outbreaks of the larch budmoth, Zeiraphera diniana. Recently, they have constructed a computer model of the interaction between the moth and larch which produces cyclic outbreaks identical to those shown by the natural population [1]. The basic host-insect interactions of this model are (1) larch trees respond to insect feeding by producing shorter, tougher needles; in other words the raw fiber content of the needles increases following heavy defoliation, and (2) this effect causes reduced larval survival and female fecundity in the year following heavy defoliation. I emphasize the delayed effect of larch budmoth feeding on its own reproduction and survival because of the well known theorem that time-delays in feedback control systems are a necessary conditon for cyclic dynamics. For example, I have shown that a very simple time-delayed feedback model describes the typical cyclic outbreaks of the Douglas-fir tussock moth [2].

Although delayed feedback interactions with the host plant may be a necessary condition for cyclic outbreaks, it is not a sufficient condition. Theoretical studies show that outbreak cycles only occur if the insect inhabits a very favorable environment. For example, tussock moth and larch budmoth outbreaks tend to be associated with particular site and/or stand conditions. Thus, cyclic outbreaks can probably be suppressed by controlling stand and site conditions [3].

[1] Fischlin, A. and W. Baltensweiler. Bull. Soc. Entomol. Suisse 52: 273-289 (1979).

[2] Berryman, A. A. Can. Entomol. 110: 513-518 (1978).

[3] Berryman, A. A. Proc. XVII IUFRO World Congr., Div. 2, 541-549 (1981).

UNDERSTANDING BARK BEETLE/HOST TREE INTERACTIONS: A MEANS TO IMPROVED DECISION MAKING STRATEGIES

F. M. Stephen

Improved decision-making capabilities are an important goal in pest management. The need to more fully understand bark beetle/host tree interactions and how this knowledge can be linked to better prediction of Dendroctonus frontalis infestation growth was discussed. The properties of pines which confer resistance to D. frontalis, a primary resin system and hypersensitive tissue response, must be correlated with bark beetle attack success, production and mortality rates. To use this information in a management-oriented predictive model, resistance properties must also be correlated to easily measurable tree and/or stand characters, which can be used to reparameterize model rates. This results in improved predictions over a variety of site and stand conditions and therefore leads to better management decisions.

IMMUNIZING PINES AGAINST BARK BEETLE ATTACK

Alan A. Berryman

Glancing through BioScience recently I came across an intriguing article by Joseph Kuć entitled "Induced immunity to plant disease" [1] which reviewed recent work with beans and cucurbits. The abstract of this article makes the following claims:

> "Plants can be systemically immunized against diseases caused by fungi, bacteria, and viruses by restricted infection with fungi, bacteria, or viruses. Immunization followed by a booster inoculation protects cucumber, watermelon, and muskmelon throughout the season, and a single immunization protects cucumber against at least 10 unrelated diseases."

My reactions to this article was "if cucumbers why not pines?" To make things even more interesting, the phenomenon of immunization seems to explain some perplexing data which Ross Miller collected the year before. He found that trees being attacked by Dendroctonus ponderosae reacted more strongly to inoculation with the beetle vectored blue-stain, Ceratocystis clavigerum, after the attak had started than before.

This summer we plan to test the immunization theory by inoculating randomly selected lodgepole pines with C. clavigerum prior to beetle flight and then caging individual beetles on these and a similar number of controls. The question is, will the trees that have experienced the pathogen be able to pitch out the pioneer beetles and contain the fungus before they are mass attacked?

[1] Kuć, J. BioScience 32: 854-860 (1982).

SILVICULTURE, PLANT VIGOR, AND BARK BEETLES

Russ Mitchell

Thinned and unthinned stands of lodgepole pine in eastern and central Oregon were evaluated to determine their vigor and susceptibility to attack by outbreak populations of the mountain pine beetle. Application of a vigor rating system based on amount of stem growth per square meter of crown leaf area showed that most thinnings from below improved the vigor of the residual stand. Vigor response was directly related to intensity of thinning and beetle mortality decreased when vigor increased, even when beetle pressure was heavy. This suggests thinning from below is a valid silvicultural treatment in Oregon (and perhaps elsewhere) to reduce mountain pine beetle damage on lodgepole pine.

PLENARY WORKSHOP: COMPUTER SOFTWARE PACKAGES FOR PRACTICAL PURPOSES
Moderator: Kathy Sheehan
Participants: C. J. DeMars, Gerry Hertel, Jim Hoy, Sandy Liebhold, Kathy Sheehan, Terry Shore

The aim of this session was to introduce those with little computer background to microcomputers and to expand the horizons of experienced "computer jocks". The session was generally focused on microcomputers, especially applications for forest entomologists.

Rick Johnsey began with another of his inspirational, but unrepeatable, introductions; he added new dimensions to certain items of computer jargon. Jim Hoy then gave a brief description of how he uses microcomputers; this "case study" is summarized below.

Jim Hoy's goal, when he first considered use of a computer, was to record the path of an animal as it was projected onto a graphics tablet, thereby avoiding frame-by-frame analysis of film. He developed a system using an Apple II+ that can record the movements of mites for up to 5 minutes, with observations every 0.1 seconds. Analysis of the path may be for speed, variation in speed, turning rate, or position relative to specified areas of the arena.

During the past two years, he's used his microcomputer for many other applications. In prepartion for field studies, he's done statistical power calculations and generated tables of non-recurring random numbers. Programs for regression and ANOVA are available. With a moderate effort, he's written a program that does rank correlations. Presentation of results is facilitated by a graphics program that makes plotting of scattergrams, bar graphs, and pie charts fast and neat. A typing tutorial and a word processor have freed him from the typing pool.

Jim noted that the amount of time required to learn to use the software should be a major consideration. The typing tutorial program can be effectively used after 20 minutes of reading. Many statistical uses become routine after and hour or two. Spread-sheet analyses often require 5-10 hours for proficiency, while the graphics plotting program can be used after 2-4 hours of practice. Regarding languages, reasonable skill in BASIC can be achieved in about 20 hours; FORTRAN, PASCAL, and LOGO are alternatives, each with special qualities.

For your primary application, Jim suggested that you choose on the basis of software that you have personally tested. If you can't resist hiring a programmer, define the job very carefully, specify that a flowchart must be included in the documentation, and be prepared for some artistic license.

Demonstrations and poster displays occupied most of this plenary workshop. Literature was available on graphics packages, field data recording devices ("automatic hygrothermographs"), agriculture-related programs that are available interactively, and general information on specific microcomputers. Several representatives from Digital Equipment Corporation (DEC) demonstrated some of their latest models. Those

wishing to familiarize themselves with local fauna were encouraged to play "Medfly Mania", provided by Dave Rowney. Other demonstrations presented by WFIWC members are summarized below.

C. J. DeMars displayed a Photointerpretation Information System (PISYS) that he has developed. PISYS is a microcomputer-based system for digitizing point location data from aerial photographs viewed with a scanning stereoscope (Old Delph). The coordinates of points of interest are digitized (Numonics Graphics Calculator), operations are controlled and data stored (Hewlett-Packard 9825A), and results either listed or plotted for display (HP 9862A). Using a least squares fit of coordinates of control points common to two photos or maps, coefficients for a bivariate linear regression useful for transferring data between photos or maps of different scales or orientation are computed. These transferred data permit the development of high quality estimates of the number of trees killed by bark beetles during a particular time period which can be correlated with factors determining life-stage survival rates.

Gerry Hertel demonstrated FERRET -- a component of an operational, computer-based decision support system for southern pine beetle management that gives users easy access to new or existing technology. Developed by Bob Coulson and associates, FERRET is available on a mainframe computer at Texas A&M University; a "dumb" terminal with capacity for telecommunications (and the telephone number!) are all that's needed to access this program. FERRET's question analysis works as follows: after the question is typed into the computer, the program offers a series of menus relative to that question, and the user is asked to indicate the appropriate category for the question. The process is repeated until the program has enough information to identify the technology(ies) available to answer the question. Discriptions of a particular technology include its purpose, limitations, qualifications on usage, where and how it can be accessed, an non-model sources of information (publications, individuals). Models currently available from FERRET include: hazard rating models (3), economic or impact evaluation models (5), stand growth and yield models (16), population dynamics models (3), and a utilization model (1).

Jim Hoy displayed the hardware and software for the arthropod tracking system that he discussed earlier. The hardware was an Apple II+ with a video camera connected through a digitizer that converts the analog signal from the camera for analysis and storage in digital code. The software controls the portion of the camera image that is analyzed, calculates the animal's location in the arena, and records elapsed time. The ultimate analysis of the path is determined by the investigator. This system has been used to record the movements of mites in an arena.

Sandy Leibhold presented a Commodore VIC-20, a microcomputer that offers many possibilities for data acquisition and management at a low price (5k VIC is $140 and 170k disk drive is $300). The addition of a $90 modem and an emulator program allows one to use the VIC as an inexpensive terminal. Sandy demonstrated the use of a 7 channel analog to digital converter that he built to allow his VIC to record environmental

factors such as temperature and light intensity over long periods of time. He also presented a program he wrote for full-screen data entry and data base management. The VIC displays only 22 characters per line on its video display, so using an unmodified VIC for most word processing applications would be a big mistake!

Sandy also presented examples of graphics generated by SAS-GRAPH and TELAGRAF, two software packages that produce publication-quality output. Both packages run on IBM mainframe computers running under CMS, TSO, or WYLBUR operating systems. TELAGRAF will draw line graphs, histograms, pie diagrams, and blocks of text. The nicest aspet of TELAGRAF is that it allows one to specify nearly all of the details of a graph (i.e., line widths, placements, and so on). SAS-GRAPH, a subset of the Statistical Analysis System statistics package, supports a wider variety of types of graphics: line graphs, pie diagrams, histograms, 3-D histograms, 3-D surfaces, maps, and blocks of text. Data sets developed by the SAS statistics programs can be used directly by SAS-GRAPH without reformatting; however, many of the details of how SAS-GRAPH lays out graphics are not modifiable. When using these packages, the factor limiting graphics quality is usually the resolution of the graphics output device, not the software.

Kathy Sheehan displayed an Apple II+ and a graphics package, Apple Plot. This package will plot 1 or 2 data sets as line graphs, histograms, or 1 line graph and 1 histogram. Titles and axis-labels are easily added. The data set you wish to plot must be on the same disk as the Apple Plot program; transferring files among disks in order to print them becomes quite tedious. Apple Plot is a very general plotting routine; it has no capacity for simple statistics or curve-fitting.

Terry Shore demonstrated a tree-ring analysis software package. Rene Alfaro (PFRC, Victoria BC) is currently using an Apple II microcomputer to carry out tree ring and stem analysis in relation to western spruce budworm impact. His system consists of a Digi-mic tree ring counter directly connected to the Apple. Terry demonstrated software that displays annual radial increment and "tree profiles" obtained from the stem analysis data. Other programs under development include programs to calculate tree volumes and volume loss attributable to budworm.

Following the demonstrations, two workshops were held. One was a "Dear Hacker", information exchange session; moderated by Jim Hoy and Dave Rowney, this was a chance for experienced computer users to share experiences with particular hardware or software systems. The other workshop was a more general, introductory session for those with little or no computer experience. For this session, C. J. DeMars first discussed uses of microcomputers (editing, storing, and retrieving data; communicating with other computers; statistical analyses; spread-sheet analyses; word processing). C. J. also discussed the principles of "top-down program planning", as illustrated by these steps: (1) problem definition, (2) mathematical specification, (3) data set description, (4) algorithm design, (5) hardware selection, (6) coding, (7) evaluation, (8) documentation, and (9) operational implementation.

WORKSHOP: MANAGEMENT
Moderator: Russ Mitchell
Participants: Don Owens, Art Stock, Dave Overhulser, Pete Lorio

This was a 2-hour workshop attended by about 60 people. The moderator noted that the workshop was to be as informal as possible and discussion was invited from all attending. Because there was considerable discussion, only four people were able to present the results of their work:

DON OWENS discussed the relationship between black stain fungus on second-growth ponderosa pine in California, attacks by the red turpentine beetle, and the probability of subsequent attack by the mountain and western pine beetles. Don found that most attacks by the turpentine beetle were associated with black stain infections, and that the number of turpentine beetle attacks was directly related to the probability of subsequent, lethal attacks by the western and mountain pine beetles.

ART STOCK described the use of prescribed, broadcast burning in British Columbia to eliminate spot infestations of the mountain pine beetle. The aim of the treatment was to reduce local beetle populations by killing all the insects in the treatment area. All trees in a sizable infestation area were felled and the down material burned on a day when weather conditions were suitable. Samples of the infested material after burning suggests the beetle population in all felled logs was eliminated. Damage to the burned site was considerable, enough that it would not likely support trees again for a long time.

DAVE OVERHULSER discussed the cranberry girdler, Chrysoteuchia topiaria, which is a pest of nursery-grown Douglas-fir and true fir seedlings in western Oregon and Washington. The pest damages seedlings by girdling the taproots. Although damage was most severe in nurseries surrounded by grass fields, the girdler could reproduce in the nursery beds. Insecticides applied to control adults and larvae effectively reduced the incidence of damage.

Dave also described a type of damage to nursery Douglas-fir where the terminal bud is damaged, resulting in undesirable seedlings with multiple tops. Since the source of damage is unknown, Dave calls it the Willamette Valley Syndrome, referring to the Oregon valley where it is most common. Damage symptoms were shown, which prompted considerable speculation about the source.

PETE LORIO observed that the forest inventory data routinely collected by foresters can often be used for evaluating and solving pest problems. As an example he noted application of such data for the development of a stand risk-rating system for the southern pine beetle.

WORKSHOP: INSECT-PLANT INTERACTIONS: DOLLAR ASPECTS IN PLANTATIONS AND YOUNG STANDS
Moderators: Bill Bedard, George Ferrell
Participants: Tom Koerber, Roy Hedden, Rick Johnsey, Paul Buffam, Bob Stevens, John Pierce, Richard S. Smith, H. Johnson, Ben Moody, Mike Wagner, Bill Beaufait, Rick Dresser, Dan Cahill, Max Meadows, John Stein, Dave Overhulser, Gary Daterman, Pat Akers, Stefan Lindgren, Art Stock, Scott Cameron.

Recognizing that insect-plant interactions are manifold, and are confounded by site and stand factors, cultural practices, and damage from diseases and other animals, discussion centered on the various types of damage and the pros and cons of various methods to measure them. As tree mortality, growth, and stem deformation all affect yield and are to some extent interactive, methods of quantifying each, and integrating their effects, were discussed. Spatial and temporal variations in damage also affect optimal utilization of the site and must also be taken into account in assessing affects on yield. Modifications of the stand life table approach, integrating the effects of the various modes of damage, were proposed. These tables could serve as the basis for age-specific stocking, growth, and yield, tables designed to determine which insects are economic pests, and whether preventative or suppressive treatments are needed. A major impediment is the lack of standards for expected yield of fully managed stands. Existing standards are frequently too conservative, being based on stands which were not pest-free during their development. Theoretical models, based on availability of light, water, and nutrients, may be unrealistic if not based on sound data. Optimally managed stands, where all factors, including insects, constraining yield have been eliminated, would be valuable, but are expensive and time-consuming to establish experimentally. Finally, it was agreed that all decisionmaking guides developed must be site-specific to be of maximum usefulness to stand managers.

WORKSHOP: PHYSIOLOGY/BIOLOGY OF FOREST INSECTS
Moderator: John H. Borden
Participants: J. C. Moser, D. L. Wood, H. C. van Keyserlingk and P. Akers

Dr. J. C. Moser presented the results of his research on the association of the southern pine beetle, Dendroctonus frontalis, the mites, Tarsonemus ips and T. krantzi, and the fungal pathogen, Ceratocystis minor. The two mites are vectors of C. minor in D. frontalis galleries.

Studies on host-produced feeding stimulants for the bark beetle, Ips paraconfusus, were reviewed by Dr. D. L. Wood. Experimental results indicate that feeding is stimulated by a combination of chemical stimulants and a physical environment which allows an appropriate thigmotactic response. Isolation of the chemicals involved will utilize subtractive bioassays in which the contribution of individual components will be assessed by removing them from a test extract following fractionation.

The close-range orientation of insects to odour sources was discussed by Dr. H. C. von Keyserlingk. The importance of moisture in the response of bark beetles to their hosts was exemplified by experiments in which Scolytus scolytus were stimulated to bore into moistened non-hosts or bark copies made of plaster of Paris. Recent studies on the orientation of flying moths to odour sources were also presented. These included the development of "end view " analysis of flight tracks in a wind tunnel which allow the assessment of movement on a cross-sectional, vertical plane, and the use of a photocell to assess the filamentous structure of "smoke" odour plumes. Comparisons between wind tunnel and field experiments showed that changes in wind direction did not induce "casting" flight. Instead, the responding moths manage to keep inside the odour plume when the wind direction changes.

Mr. R. P. Akers addressed the task of elucidating the various components of odour discrimination by Ips paraconfusus. In a diffuse light olfactometer that produces random orientation, exposure to pheromone odour produced low and highly variable changes in walking and turning rates. These kinetic responses are therefore unsuitable as a measure of pheromone perception.

WORKSHOP: ECOLOGY

Moderator: Sandy Liebhold

Participants: Torolf Torgersen, Mitchel Miller, Ronald Stark

Torgy Torgersen gave a summary of work he and Bob Cambell have been doing with the effect of natural enemies on western spruce budworm population dynamics. Most of their work has involved the use of exclosures to determine the effect of excluding different agents on survival. They have used tanglefoot, whole branch cages and whole tree cages in a variety of budworm population conditions. They found that survival may be as much as 18 times greater on protected foliage. They feel that foliage foraging ants are the most important factor in the lower crown and insectivorous birds are most effective in the upper crown. There is apparently compensatory mortality between these two agents. They have observed low parasitism rates (5-6%) and therefore, suspect that they are not important factors. Torgy feels that silvicultural prescriptions could be developed to favor ant populations. This summer Torgy and Bob will examine predation processes and intra-tree larval and pupal distribution at sites in New Mexico. In cooperation with Rex Cates, University of New Mexico, they will study the effects of host foliage quality on larval and pupal development, survival, and fecundity.

Mitch Miller presented some preliminary results of his work on the insect natural enemy contribution to *Ips calligraphus* mortality. Replicated treatments of fine mesh exclusion cages (insect exclusion), coarse mesh exclusion cages (sawyer exclusion), and complete exposure to insect associates of bolt sections attacked by *Ips calligraphus* populations showed that the impact of insect associates on the within-tree *Ips calligraphus* population varies with season. From May to July there was a significant reduction in adult beetle emergence caused by insect associates. However, the effect of insect natural enemies alone on adult emergence was not significantly different from the combined effect of sawyers and insect natural enemies. After July, emergence of *Ips calligraphus* did not differ significantly from bolts which excluded all insect associates and those that excluded only large sawyers. The effect of insect natural enemies was minimal ; the effect of sawyers was considerable.

Ron Stark presented some preliminary results of work he has done with the population dynamics of the larch casebearer. He feels that microclimate is an important factor effecting larch casebearer populations. A series of violent storms occurred during the 1981 larch casebearer flight period resulting in lower than expected egg deposition. In addition, a high degree of unexplained mortality of pupae was thought to be due to excess heat and/or low humidity. Parasitism rates are effected by altitude and forest species composition. Ron described work done by Chris Niwa and Richard Nathanson, graduate students at the Univ. of Idaho, in which the latter compared parasitism rates in forests with scarafied understories and in untreated stands. Surprisingly parasitism rates were greater in the scarafied stands. Chris Niwa's work showed that microclimate affects parasite distribution. *Agathis pumila*, an introduced parasite did not become established in xeric release sites.

THIRTY-FOURTH WESTERN FOREST INSECT WORK CONFERENCE

Minutes of Final Business Meeting
Santa Rosa, California, March 3, 1983

Chairperson Stark called the meeting to order at 3:30 p.m.

Chairperson Stark indicated that the Executive Committee will be involved in program planning for the 1984 meeting to be held in Oregon. Kareen Sturgeon, Chairperson of the 1984 Arrangements Committee, called for members' reactions to the 1983 meeting.

An invitation written by Bob Stevens and Bernie Raimo to hold the 1985 Conference in Colorado, was read to members.

The Nominating Committee chaired by Jackie Robertson honored Stu Whitney's recommendation and nominated Peter M. Hall to replace Stu as Counselor.

Torgy Torgersen reported on the open session of the Common Names Committee and of interested Conference members. Two new names were approved: sixspined ips for Ips calligraphus and eastern five-spined ips for Ips grandicollis. The Committee also determined that the name change from western spruce budworm to western budworm for Choristoneura occidentalis is desirable and appropriate.

Chairperson Stark suggested that, because of the broad interest in Choristoneura species, and the far-reaching effects of the proposed name change of western budworm for C. occidentalis, that a mail ballot survey of the members-at-large might be appropriate to establish a concensus. John Borden moved and Kathy Sheehan seconded a motion to conduct a mail ballot survey of the proposed name change. Motion carried; vote was not unanimous.

The Ethical Practices Committee Report, because of the absence of Surrogate Chairperson Rick Johnsey, had been turned over to and was read by Ron Stark. Rick reported a very poor performance which gave rise to suggestions that we establish a new Wimp of the Year Award. Two unnamed Berkeley professors were immediately suggested as candidates for not driving the few miles to attend the Conference. When Rick had turned over information to Chairperson Stark, he had concluded that no one had earned the tribute of Chairperson of the EPC and it should be put in mothballs for a year.

However, after Johnsey left the Conference, activity seemed to increase and reports began to trickle in after the banquet at Souverain Winery. Several events took place which at least presented some candidates; Lorio's apparent moribund condition which almost caused a maid to call the coroner; a talent for obscene phone calls demonstrated by several young people of the female persuasion; Sturgeon, Robertson, and Matson showed promise by outlasting the Souverain staff and, later, several other Conference members. However, none of these measured up to the high standards of this office.

However, one individual, although noted for bizarre behavior, had maintained a pace exceeding his norm. From starting the week by playing Paul Revere and announcing the GAO is coming to an apparent attempt to walk on water to acting the role of supply sergeant he kept his pace. The last night he showed staying power by dancing with most of the women and several of the men, closing the bar, and then continuing until the wee hours of the morning.

Wilfred Freeman graciously accepted and displayed his award properly to a rousing applause even though he thought all claims were grossly exaggerated. He went on to say that this was proof that one needs not be uncouth and that "a perfect gentleman can become Chairperson."

Chairperson Stark moved a vote of thanks to John Dale and Jackie Robertson for their work in Conference arrangements and program planning.

The meeting adjourned at 3:40 p.m.

TREASURER'S REPORT

Thirty-fourth Western Forest Insect Work Conference
Santa Rosa, California, March 3, 1983

Balance on hand March 1, 1983	(+)	$ 557.80
Expenses:		
Coffee	(-)	$ 238.50
Computer rental	(-)	$ 60.00
Income:		
Registration (128)	(+)	$2,185.00
Sale of 1982 Proceedings	(+)	$ 9.00
Sale of raffle tickets	(+)	$ 9.00
Balance on hand March 3, 1983	(+)	$2,462.30

CONSTITUTION
OF
WESTERN FOREST INSECT WORK CONFERENCE

Article I Name

The name of this organization shall be the Western Forest Insect Work Conference.

Article II Objects

The objects of this organization are (1) to advance the science and practice of forest entomology, (2) to provide a medium of exchange of professional thought, and (3) to serve as a clearing house for technical information on forest insect problems of the western United States and Canada.

Article III Membership

Membership in this organization shall consist of forest entomologists and others interested in the field of professional forest entomology. Official members shall be those who pay registration fees.

Article IV Officers and Duties

The officers of this organization shall be:

(1) A Chairman to act for a period of two meetings, whose duties shall be to call and preside at meetings and to provide leadership in carrying out other functions of this organization.

(2) An Immediate Past Chairman, who shall assume office immediately upon retiring as Chairman without further election; whose duties shall be to fill the chair at any meeting in the absence of the Chairman; to act until the election of a new Chairman.

(3) A Secretary-Treasurer to act for a period of two meetings whose duties shall be to keep a record of membership, business transacted by the organization, funds collected and disbursed and to send out notices and reports. The Secretary-Treasurer is charged with the responsibility of preparing the proceedings for the conference in which his term of office is terminated (amended Feb. 28, 1967, Las Vegas, Nevada).

(4) An Executive Committee of six members, consisting of Chairman, Immediate Past Chairman, Secretary-Treasurer, and three Counsellors elected from the membership. Terms of office for the three Counsellors shall be staggered and for a period of three meetings each. The duties of this Committee shall be to carry out actions authorized by the Conference; to authorize expenditures of funds, and to establish policies and procedures for the purpose of carrying out the functions of the organization. The Conference registration fee will be set by the local Arrangements Committee in consultation with the Secretary-Treasurer and Chairman (amended March 4, 1965, Denver, Colorado).

The officers shall be elected at the Annual Meeting. Their periods of office shall begin at the conclusion of the meeting of their election.

The Chairman shall have the power to appoint members to fill vacancies on the Executive Committee occurring between meetings. The appointment to stand until the conclusion of the next general meeting.

It is the responsibility of a Counsellor, should he be unable to attend an executive meeting, to appoint an alternate to attend the executive meeting and to advise the Chairman in writing accordingly. The alternate shall have full voting privileges at the meeting to which he is designated.

Article V Meetings

The objectives of this organization may be reached by holding of at least an annual conference and such other meetings as the Chairman, with the consent of the Executive Committee, may call. The place and date of the annual shall be determined by the Executive Committee after considering any action or recommendation of the conference as a whole. The Secretary-General shall advise members of the date and place of meetings at least three months in advance.

Article VI Proceedings

A record of proceedings of conference shall be maintained and copies provided to members in such form as may be decided as appropriate and feasible by the Executive Committee.

Article VII Amendments

Amendments to the Constitution may be made by a two-thirds vote of the total conference membership attending any annual meeting.

Prepared by Richard Washburn
March 20, 1969.

WESTERN FOREST INSECT WORK CONFERENCE MEMBERSHIP ROSTER

Name	From	Address	City, State, Zip Code	Country	Phone Number
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